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Band stop filters for THz waves based on dielectric metasurfaces

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Abstract- In this work, we propose and design a dielectric metasurface based on Silicon (Si) subwavelength pillars. A previous study of the directional conditions of the scattering is carried out in order to obtain the optimum sizes. The metasurface can operate as a band-stop filter to realize blocking back THz waves in the designed band range, while transparent transmission over the rest of the range.

Nowadays, most of the frequency spectrum has been exploited. Despite this, the gap between microwaves and infrared is still in a research stage. This range known as 'terahertz gap' corresponds to frequencies from 0.3 THz to 3 THz. Recent advances in THz sources and detectors have accelerated the THz application and techniques. Some of the most relevant applications are biosensors [1], security [2] and high speed communication [3]. However, in addition to efficient sources and detectors, these applications also require other optical devices to control and manipulate these kind of waves.

The research of dielectric metasurfaces has attract a lot of interest in recent years. Some applications are planar photonics [4], flat optics [5] and flat lenses [6]. These kind of structures have opened new venues of research in the control of THz frequencies. The use of dielectric materials produces low insertion losses in comparison with metallic counterparts but similar effects when an overlap of the electric and magnetic-dipole resonances are produced. Moreover, in some cases as Si, the CMOS compatibility makes an easy integration with other kind of optical devices. In this work, it is demonstrated how the use of Si subwavelength pillars can be used in order to create selective filters for THz waves. A previous study of the directional conditions of the scattering is carried out in order to obtain optimum sizes. By using this study it is possible to choose the stop-band of the filter. The Si pillars are placed on a substrate of a low-loss THz polymer.

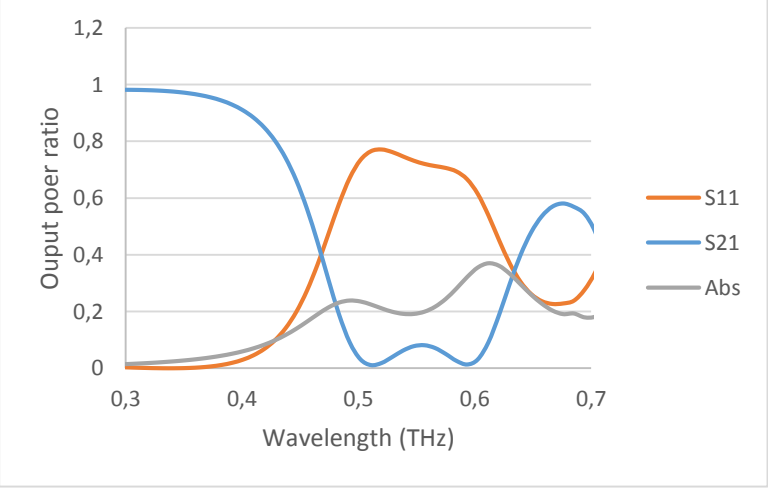

Figure 1. Band stop filter in the region between 0.5 to 0.6 THz.

As an example, Fig. 1 shows the result of a metasurface designed to have the band rejection around 0.5THz. The nanopillars are structured in a metasurface configuration with a periodic space between nanopillars of 100μm. The structure is based on Si nanopillars with height 180μm and radius 70μm. The metasurface can operate as a band-stop filter to realize blocking back THz waves in a band range of 0.5–0.6 THz, while transparent transmission over a range of 0.1–0.4 THz. As can be observed, for this specific design a range of 100GHz can be filtered. The transmission is almost zero in this range, indicating an optimum rejection band. The interesting THz band-stop filtering properties suggest a promising application in the modern THz communication systems, THz time-domain spectroscopic imaging and THz continuous wave imaging.

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REFERENCES

1. H.-B. Liu, G. Plopper, S. Earley, Y. Chen, B. Ferguson, and X.-C. Zhang, “Sensing minute changes in biological cell monolayers with THz differential time-domain spectroscopy,” Biosens. Bioelectron. 22, 1075–1080 (2007).
2. J. F. Federici, B. Schulkin, F. Huang, D. Gary, R. Barat, F. Oliveira, and D. Zimdars, “THz imaging and sensing for security applications-explosives, weapons and drugs,” Semicond. Sci. Technol. 20, 266–280 (2005).
3. I. F. Akyildiz, J. Jornet, C. Han, “Terahertz band: Next frontier for wireless communications,” Phys. Comm., 12, 16-3 (2014).
4. Kildishev, A. V., Boltasseva, A. & Shalaev, V. M. Planar photonics with metasurfaces. Science 339, 1232009 (2013).
5. Yu, N. & Capasso, F. Flat optics with designer metasurfaces. Nature Mater. 13, 139–150 (2014).
6. Quanlong Yang, Jianqiang Gu, Dongyang Wang, Xueqian Zhang, Zhen Tian, Chunmei Ouyang, Ranjan Singh, Jiaguang Han, and Weili Zhang, "Efficient flat metasurface lens for terahertz imaging," Opt. Express 22, 25931-25939 (2014)